RESEARCH PROPOSAL

A Study on Multi-Index Transshipment Problem

submitted to

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED (M.S.)

for the partial fulfilment of award of degree of

Doctor of Philosophy

In

Statistics

Under the faculty of Science and Technology

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July 2023

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1. Abstract

A Transshipment Problem (TSP) may be viewed upon as a sub-entity of the regular Transportation Problem (TP), wherein the units or goods or services to be shipped are sent from a source first usually to a mid-point referred to as a transshipment point, and then are sent to the destination thereon [4]. Sita Bhaskaran [1] presents that if daily or frequent shipments of materials are demanded from sources or suppliers, it results into a large number of small shipments that are expensive to ship. For efficient transportation of such small shipments, transshipment is essential. While the regular Transshipment Problem focuses on minimizing just the incurred transportation cost, the Fixed Cost Transshipment Problem (FCTSP) will consider inclusion of various other factors viz. transportation time, fixed costs at one or more transient points involved in the shipping route, preference indices of particular sources or transitory points, priority indices corresponding to due transportation cost and desired time duration of transportation, etc. Through FCTSP, the research is intended at extending the objective of the regular Transshipment Problem to optimization of multiple factors, all the while being bound by the same constraints, restrictions and requirements of the regular form of the Transshipment Problem with at least one transshipment/ transient point considered from a source en route to a sink. Exploration of Transshipment Problems (Lateral Transshipment) in Inventory management is also intended.

2. Introduction:

The field of Operations Research, Transportation Problem (TP) is a very widely applied and applicable area. The objective of solving a Transportation Problem is to determine the best possible shipping schedule of articles from sources (also referred to as origins) to destinations (also referred to as sinks), i.e. the optimum shipping schedule, which will minimize the total cost of transportation incurred. The demands of quantities of a commodity at various destinations are met by shipping the units to them from various sources according to the available supplies.

Transportation Problems require that an article be shipped to a destination directly from a source, with no stoppages or transfer points in between. Given this requirement/condition; if there is a source A, and two destinations, say B and C that lie along the same route with B closer to A than C without loss of generality. Then, to transport a certain number of units from

A to B and C, there would be two separate shipping schedules, viz. A to B and A to C to meet the destination demands. The fact that B and C are in fact along the same route could present an opportunity for savings in resources, but does not find place in regular TP. Here is where a Transshipment Problem (TSP) displays its advantage. the Transshipment Problem (TSP) makes room for the fact that shipping articles through transitory points, rather than shipping them from sources directly to destinations, could in fact result into shipping schedules that result into considerably lower transportation costs. If allowance is provided for at least one transshipment point, i.e. a point of interruption between the source and the sink, it results into transportation costs that are lower than the minimum incurred transportation cost as obtained from the optimum shipping schedule resulting from the regular Transportation Problem. As established by Martina Bris [4] and Archana Khurana [7], Transshipments usually are less expensive as compared to direct shipments. So in the hypothetical scenario of destinations B and C considered above, there would be allowance wherein destination B could be a transitory point.

Like in the case of a regular transportation problem, the optimum solution of a Transshipment Problem also is based only on the per unit transportation costs. The possible existence of another cost factor, which is a fixed charge, i.e. an amount that needs to be paid irrespective of the shipped quantities is not taken into consideration. Such fixed charges/costs could represent a cause of concern, as there is a possibility of the variable per-unit transportation cost being over-shadowed by the fixed charge. The Transshipment Problem is viewed upon as an improvisation of the regular Transportation Problem. The Fixed Charge Transshipment Problem (FCTSP) is a relatively less explored territory and is certainly worthy of special consideration.

3. Review of Literature and Development in the subject:

Martina Bris [4] attempts to find, via computer and mathematical modelling, the ideal number of stoppages/ transfer points should be introduced into the system under consideration, and also whether or not their capacities should be kept restricted. The article discusses costs classified as motion costs and holding costs incurred along the path from production to consumption of the product. This path covers carrying, holding, loading, transporting and unloading [2]. Owing to the high levels of spoilage and/or damage which, in turn results into clear financial losses, management of perishable products has always been and still is true

challenge for relevant markets and retail [9]. The importance of FCTSP and an accompanying lateral approach is highlighted when while solving problems of relocation, it becomes essential to take into account two objectives, namely minimization of unsatisfied demand, and the minimization of total transportation and inventory holding costs. In such situations, a cost-efficient solution becomes more important. [6]. Jay R. Brown, Alfred L. Guiffrida [5], have developed successfully, a green-based supply chain optimization model for use in managing transportation policy; giving the study an angle of environment sustainability. Agadaga, G.O. and Akpan, N.P [10] propose that although the transshipment problem is an extension of the TP, the optimum solution may be easily found by converting the transshipment problem into an equivalent transportation problem, and finding the solution by regular techniques. If this is found doable for all cases, then the applicability of the algorithm significantly broadens. Suk-Chul Rim, JingJing Jiang [11] put forth notably unique contributions; viz. a realistic albeit complicating consideration of transshipment cost as proportional to the number of trucks; irrespective of the truckload; determination of the optimal transshipment is determined as a function of the length of time window during which transshipment is carried out; and consideration of volume constraint of items to transship. The justification seemingly valid is that it is not unusual for the total volume to transship to exceed a volume capacity of a small delivery truck given the varying sizes of goods to be shipped. These three contributions will make our model to be more useful in logistics practice. Archana Khurana [7] presents an algorithm to find out the efficient cost-time trade-off pairs for the three dimensional fixed charge bi-criterion transshipment problem which is modelled to assign equal priority to cost as well as time. A related fixed charge bi-criterion three dimensional transportation problem is formed to find out the efficient cost-time trade off pairs for the given problem, which also yields efficient cost-time trade-off pairs. As aptly by stated Ashok Kumar et.al. [13] the formulation of transshipment problems involves knowledge of parameters such as available supplies, demands, factors such as related costs, time, etc. However, factors such as unavailability of exact details, weather conditions, certain unobtainable pieces of information give rise to uncertainties in formulating transshipment problem. A fuzzy approach is suggested to handle these uncertainties amicably, by considering a fully fuzzy transhipment problem

4. Objectives of the Research:

Some of the proposed objectives of the research are:

- Analytical study of existing algorithms developed to solve Fixed Charge Transshipment Problems.
- To develop algorithms that will yield modified solutions to existing single objectives.
- To develop algorithms for optimum solution of Fixed Charge Transshipment Problem with additionally introduced components as factors of the objective function.
- To validate developed models for various datasets.
- To explore the possibility of development of hybrid models.
- To explore applications of Transshipment Problems in Inventory Management.

During the period of research newer and more innovative objectives may come to foreground, which would be beneficial for the society at large.

5. Methodology:

Based on the review of the work previously done on Transshipment Problems, in this study, research can be carried out by analysis of existing algorithms that exist to solve Fixed Charge Transshipment Problems on various available datasets. The research requires various different kinds of databases, tools and techniques, scientific languages, different software and packages. The research methodology will use software packages listed below to analyze and validate the existing as well as newly developed algorithms.

➢ **Software and Packages**

- TORA
- R
- MS - Excel
- MINITAB
- MATLAB

Using the above listed software, the feasibility of an algorithm newly developed can be assessed, along with its efficacy.

6. Importance of Study/Society application:

- **Some diversified applications**

  - TSP is applicable to inventory control problems associated with perishable or short life cycle products viz. blood, fresh and packaged foods, flowers, transportation schedules in airline and hotel and pharmaceutical industries. [3]
  - Unforeseen incidents which frequently occur in the aftermath of a disaster lead to sudden changes in demands while humanitarian organizations and activists are in action. As fast delivery of relief items to the affected regions is crucial, in situations such as these, the obvious reaction would be to deliver them from neighbouring regions. Considering the relevant demand and possible future developments, what is required is an integrated relocation and distribution planning approach. [6]
  - Every milliliter of fossil fuels/ non-renewable energy resources consumed adds to the carbon footprint that is left behind. Explicit inclusion of the carbon footprint for motor carrier transportation [5] is a major pushing factor for consideration of TSP over usual TP.

- **Significance of the study**

  - Possible vehicle routing problem where both pickup and delivery over multiple locations are considered for transshipment may be considered. In this case volume constraint will become a critical one. As volume constraint is considered, an index for item is added to the formulation. [11]
  - Although TSP is fairly explored, there is always something that can add value to existing work done. The additional consideration of fixed charges and multiple indices will offer a rarely seen before approach to attempt to revolutionize the way transport of articles is executed.
  - In today's fast moving times, many are found tending to value convenience more than the costs incurred for a particular process. The same tendencies are extendable to receiving goods as well. The multi-index approach proposed herein this research will consider the prioritization of conveniences.

7. Proposed work Plan/ Formulation and Structure of Study:

- **Year wise Plan of work and targets to be achieved**

➢ **First Year**

1. Collection and review of literature on Transshipment Problems and their variations proposed and handled so far.
2. Collection, study and validation of different existing methodologies for solving single and bi-objective Transshipment Problems and Fixed Charge Transshipment Problems.
3. Attempt to develop a hybrid form of a Transshipment Problem.

➢ **Second Year**

1. Attempt to develop algorithms for single and bi-objective Fixed Charge Transshipment Problems.
2. Attempt to develop algorithms for tri-objective Fixed Charge Transshipment Problems.
3. Attempt to develop algorithms for multi-objective Fixed Charge Transshipment Problems.
4. Attempt to develop algorithms for multi-objective Fixed Charge Transportation Problems with a possibility of uncertain environment.

➢ **Third Year**

1. Publication of the findings of the research.
2. Publication of papers in various national and international journals & conferences.
3. Thesis writing.

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Date: ____ /____/ 2023